ATSDR's Conclusion for Bear Creek Valley and UEFPC Watersheds

The most successful remediation efforts in FY 2002 and FY 2003 occurred in Bear Creek Valley. The uranium flux throughout the watershed decreased markedly. The EEVOC plume in the UEFPC Watershed has been subject to aggressive pump and treat remedial efforts since August of 1999 when an action memorandum was issued to begin installation and testing of a groundwater extraction well. Actual pumping of the plume commenced in June of 2000. Administrative controls set forth in the 1997 Interim ROD for Union Valley are deemed protective of public health. Since the EEVOC groundwater plume extends off-site into Union Valley, ATSDR scientists will evaluate possible exposure scenarios for this area in the *Evaluation of Environmental Contamination and Potential Exposure Pathways* section of this document.

II.G. Land Use and Natural Resources

When the ORR was acquired in 1942, the government reserved a section of the reservation (about 14,000 acres out of the total of approximately 58,575) for housing, businesses, and support services (ChemRisk 1993d; ORNL 2002). In 1959, that section of the ORR was turned into the independently governed city of Oak Ridge. This self-governing area has parks, homes, stores, schools, offices, and industrial areas (ChemRisk 1993d).

The majority of residences in Oak Ridge are located along the northern and eastern borders of the ORR (Bechtel Jacobs Company LLC et al. 1999). However, since the 1950s, the urban population of Oak Ridge has grown toward the west. As a result of this expansion, the property lines of many homes in the city's western section border the ORR property (Faust 1993 as cited in ChemRisk 1993d). Apart from these urban sections, the areas close to the ORR continue to be mainly rural, as they have historically been (Bechtel Jacobs Company LLC et al. 1999; ChemRisk 1993d). The closest homes to X-10 are located near Jones Island, about 2.5 to 3.0 miles southwest of the main facility (ChemRisk 1993d).

In 2002, the ORR measured 34,235 acres, which includes the three main DOE facilities: Y-12, X-10, and K-25 (ORNL 2002). The majority of the ORR is situated within the city limits of Oak Ridge. These DOE facilities constitute approximately 30% of the reservation; the remaining 70% of the reservation was turned into the National Environmental Research Park in 1980. This park was created so that protected land could be used for environmental education and research, and to show that the development of energy technology could be compatible with a quality environment (EUWG 1998). A large amount of land at the ORR that was formerly cleared for farmland has grown into full forests over the past several decades. Sections of this land contain areas called "deep forest" that include flora and fauna considered ecologically significant, and portions of the reservation are regarded as biologically rich (SAIC 2002).

Historically, forestry and agriculture (beef and dairy cattle) have constituted the primary uses of land in the area around the reservation. However, these uses of land are both declining. For several years, milk produced in the area was bottled for local distribution, whereas beef cattle from the area were sold, slaughtered, and nationally distributed. In addition, tobacco, soybeans, corn, and wheat were the primary crops grown in the area. Also, small game and waterfowl were hunted on a regular basis in the ORR area, but deer were hunted during specific time periods

(ChemRisk 1993d). Waterfowl and small game hunting regularly occurs within the ORR area, while deer hunting occurs annually on the ORR (ChemRisk 1993d). During the annual deer hunts, radiological monitoring is conducted on all deer prior to their release to the hunters. Monitoring is conducted to ensure that none of the animals contain quantities of radionuclides that could cause "significant internal exposure" to the consumer (Teasley 1995).

The southern and western boundaries of the ORR are formed by the Clinch River; Poplar Creek and East Fork Poplar Creek drain the ORR to the north and west (Jacobs EM Team 1997b). White Oak Creek, which travels south along the eastern border of the X-10 site, flows into White Oak Lake, over White Oak Dam, and into the White Oak Creek Embayment before meeting the Clinch River at CRM 20.8 (ChemRisk 1993b, 1999a; TDOH 2000; U.S. DOE 2002a). Ultimately, every surface water system on the reservation drains into the Clinch River (ChemRisk 19993b). The Lower Watts Bar Reservoir is situated downstream of the ORR, extending from the confluence of the Clinch and Tennessee Rivers to the Watts Bar Dam (U.S. DOE 1995a as cited in ATSDR 1996). As a result, the Clinch River and the Lower Watts Bar Reservoir have received contaminants associated with X-10 operations (Jacobs EM Team 1997b; U.S. DOE 1995a; U.S. DOE 2001a). Please see Figure 1 for these relative water systems.

The majority of land around the Clinch River and the Lower Watts Bar Reservoir is undeveloped and wooded. Other than activities at the ORR, there is minimal industrial development in these surrounding areas, and there is a fair amount of residential growth. The public has access to the Clinch River and to the Lower Watts Bar Reservoir, which it uses for recreational purposes such as boating, swimming, fishing, water skiing, and shoreline activities (U.S. DOE 1996d, 2001b, 2003b).

Land use in Union Valley, just east of the Y-12 complex, is zoned by the City of Oak Ridge primarily as "Forestry, Agriculture, Industry, and Research District". The land over the presumed extent of the off-site contaminant plume is zoned as "Industrial District 2". None of the current landowners in Union Valley extract groundwater for residential use. Extracted groundwater from dewatering of the quarry on lot Excess (613) by Rogers Group, Inc. is discharged to surface water. No contamination has been found in the quarry water. The closest "One-Family Residential District" is 2.25 miles east of the known extent of the EEVOC plume (DOE 1997).

None of the current landowners in Union Valley extract groundwater for residential use. The nearest residential well is over 2 miles from the EEVOC groundwater plume.

II.H. Demographics

Demographic data provide information on the size and characteristics of a given population. ATSDR examined demographic data to determine the number of people living in the vicinity of the ORR and to determine the presence of sensitive populations, such as children (age 6 years and younger), women of childbearing age (age 15 to 44 years), and the elderly (age 65 years and older). According to the 2000 U.S. Census, 153 children, 403 women of childbearing age, and 423 elderly persons live within a quarter mile from the ORR; and 778 children, 1,935 women of childbearing age, and 1,681 elderly persons live within a mile of the ORR (see Figure 15).

Demographics also provide details on population mobility and residential history in a particular area. This information helps ATSDR evaluate how long residents might have been exposed to

environmental contaminants. The number of people living in the counties surrounding the ORR from 1940 to 2000, are listed in Table 6.

Table 6: Population of Surrounding Counties from 1940 to 2000

County	*1940*	*1950*	*1960*	*1970*	*1980*	*1990*	*2000*
Anderson County	26,504	59,407	60,032	60,300	67,346	68,250	71,330
Blount County	41,116	54,691	57,525	63,744	77,770	85,969	105,823
Knox County	178,468	223,007	250,523	276,293	319,694	335,749	382,032
Loudon County	19,838	23,182	23,757	24,266	28,553	31,255	39,086
Meigs County	6,393	6,080	5,160	5,219	7,431	8,033	11,086
Morgan County	15,242	15,727	14,304	13,619	16,604	17,300	19,757
Rhea County	16,353	16,041	15,863	17,202	24,235	24,344	28,400
Roane County	27,795	31,665	39,133	38,881	48,425	47,227	51,910

Sources: U.S. Bureau of the Census 1900–1990, 2000

Figure 15 shows the demographics within a 5 mile radius of the ORR boundary. As previously mentioned, most of the residents of the Oak Ridge and surrounding communities, live along the northern and northeastern borders of the site. Figure 16 shows the population distribution within a one and 3 mile radius of the Y-12 complex – the only area where groundwater contamination has migrated off-site. Surrounding the area of known off-site EEVOC plume, along Union Valley Road to the east-northeast of the Y-12 complex, there are no residences. For more information concerning the demographics of the surrounding towns please refer to the following Public Health Assessments: Former K-25 and S-50 Sites Air Releases, Y-12 Uranium Releases, and White Oak Creek Radionuclide Releases.

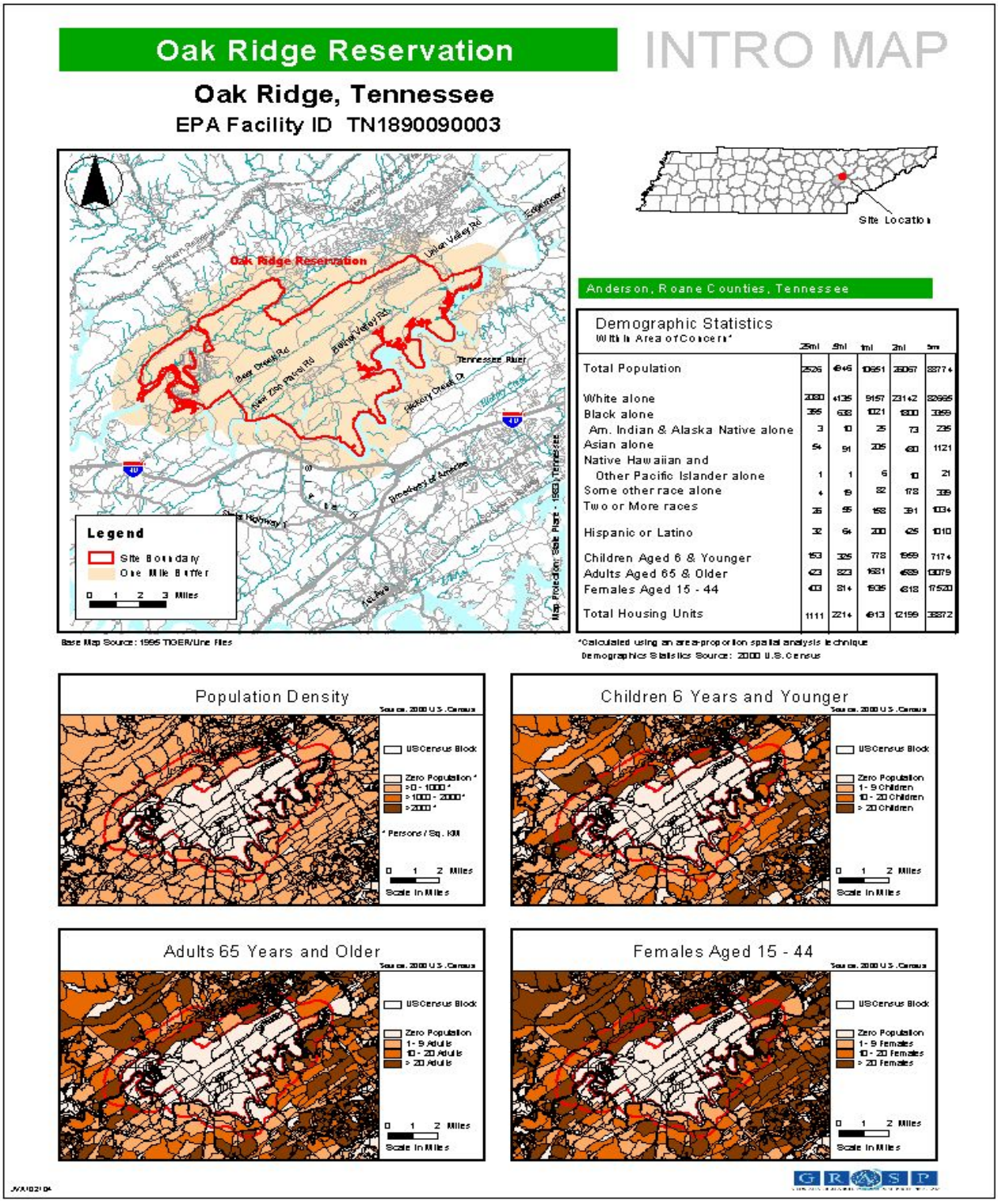

Figure 15: Demographics Within 5 Miles of ORR

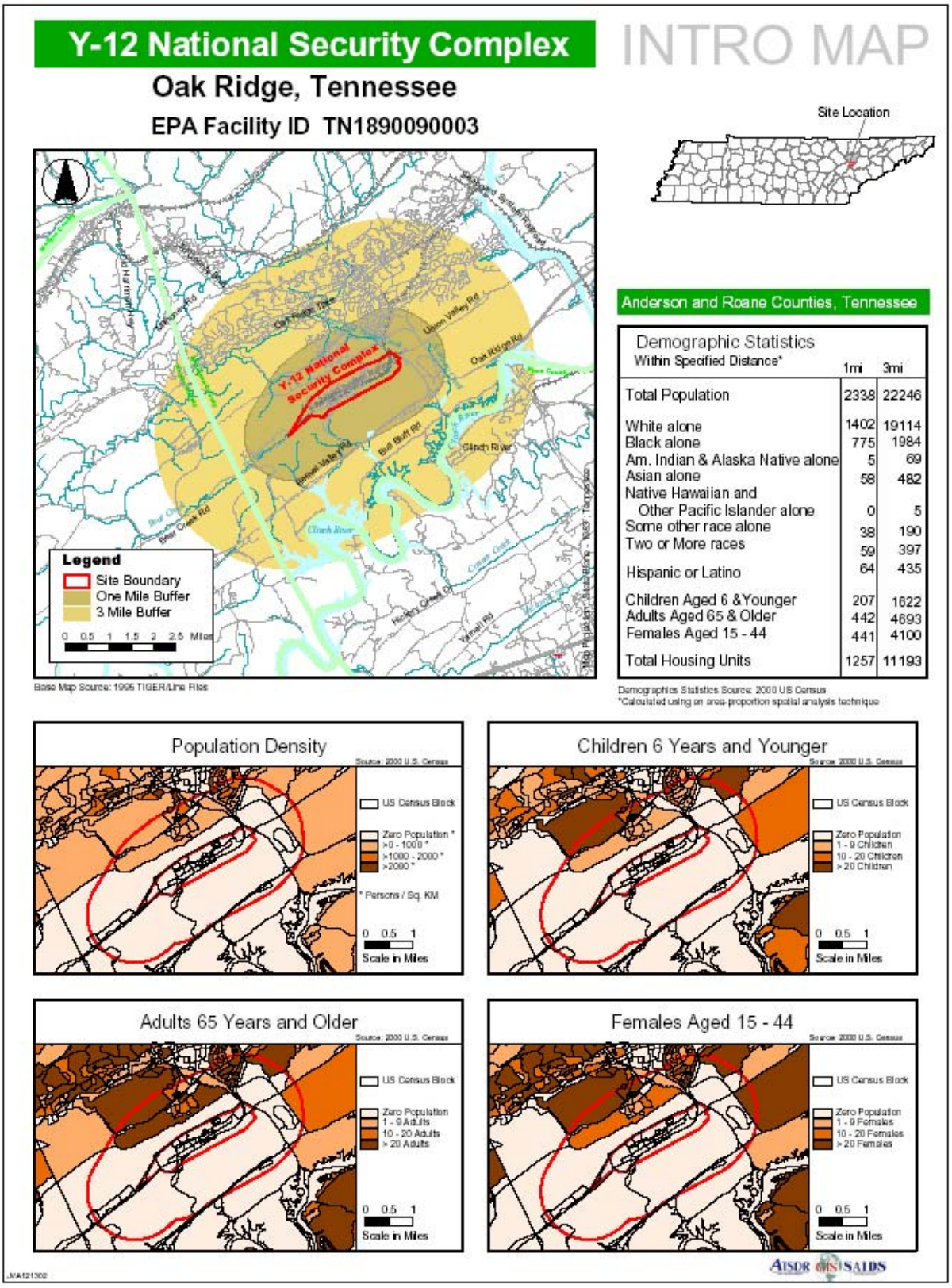

Figure 16: Demographics within 1 and 3 miles of the Y-12 Complex

III. Evaluation of Environmental Contamination and Potential Exposure Pathways

A release of a contaminant from a site does not always mean that the substance will have a negative impact on a member of the off-site community. For a substance to pose a potential health problem, exposure must first occur. Human exposure to a substance depends on whether a person comes in contact with the contaminant, for example by breathing, eating, drinking, or touching a substance containing it. If no one comes into contact with a contaminant, then no exposure occurs—and thus no health effects can occur. Even if the site is inaccessible to the public, contaminants can move through the environment to locations where people could come into contact with them.

ATSDR evaluates site conditions to determine if people could have been or could be exposed to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, water, air, waste, or biota) has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation. ATSDR also identifies an exposure pathway as *completed* or *potential,* or *eliminates the pathway from further evaluation*. Completed exposure pathways exist if all elements of a human exposure are present. A release of a chemical or radioactive material into the environment does not always result in *human exposure*. For an exposure to occur, a *completed exposure pathway* must exist. A *completed exposure pathway* exists when all of the following five elements are present:

1. a source of contamination,
2. an environmental medium through which the contaminant is transported,
3. a point of human exposure,
4. a route of human exposure, and
5. an exposed population.

A *potential exposure pathway* exists when one or more of the elements are missing but available information indicates possible human exposure. An *incomplete exposure pathway* exists when one or more of the elements are missing and available information indicates that human exposure is unlikely to occur (ATSDR 2001). In addition, for each exposure pathway ATSDR scientists identify whether releases of contaminants and exposures are likely to have occurred in the past, are currently occurring, or could potentially occur in the future.

In preparing this PHA, ATSDR reviewed and evaluated environmental data provided to ATSDR scientists directly from the Department of Energy or in various reports prepared by the Environmental Protection Agency Region IV, the Tennessee Department of Environment and Conservation (TDEC) DOE Oversight Division, or their contractors. ATSDRs evaluation included the identification of inconsistencies and data gaps. The validity of analyses and conclusions drawn in this PHA are based on the reliability of the information referenced in reports related to the Oak Ridge Reservation (ORR). In our assessment, the quality of environmental data available in these documents is sufficient for public health decisions.

This public health assessment is exclusively focused on human exposure to off-site groundwater. Exposure to other media is discussed in other health assessments of ORR performed by ATSDR.

Since off-site groundwater contamination only occurs in the area immediately east of Y-12, in Union Valley, this is the only area where exposure scenarios are evaluated. ATSDR scientists have identified three possible exposure scenarios to the EEVOC plume (Table 9). The first exposure scenario involves withdrawal of groundwater for personal use from private groundwater wells. This exposure pathway was eliminated because there is no point of exposure, and there is no receptor population. No groundwater contaminant has been detected above CVs in residential wells, except one sample collected near ETTP in 1998 where boron was detected at a concentration slightly higher than the CV. As previously mentioned, the closest residential well to the EEVOC plume is approximately 2.25 miles away. There is no groundwater being withdrawn for personal use in Union Valley. Institutional controls implemented in accordance with the Interim ROD for Union Valley (DOE 1997) serve to help ensure that no one is drinking contaminated groundwater now or in the future. Residents near ORR who are consuming groundwater are not being exposed to contamination emanating from ORR.

Site-related contaminants have not been detected beyond the ORR boundaries near either the ETTP or the ORNL.

The second exposure scenario evaluated was the possibility of someone coming in direct contact with groundwater at seeps or springs in Union Valley. Since the land overlying the known extent of the contaminant plume is zoned as "Industrial District 2", it is unlikely that individuals will come in contact with springs or seeps in this area. Also, most groundwater surfaces as diffuse discharge directly into Scarboro Creek. Indeed, groundwater constitutes the baseflow for Scarboro Creek in Union Valley (Figure 11). So, it is unlikely that individuals will come into direct contact with groundwater in seeps and springs before dilution with surface water occurs. Exposures to ORR related contaminants in surface waters are excluded in this PHA but are addressed in various other PHAs including: the White Oak Creek PHA, Y-12 Uranium PHA, and the Current and Future Chemical PHAs.

Based upon currently available data, there are no *completed exposure pathways* for ingestion or direct contact with off-site groundwater. Because of the shallow water table at ORR and the high interconnectivity of the groundwater with the surface water, contaminated groundwater transport is typically along short flow-paths to surface water. The EEVOC plume, east of the Y-12 complex, is the only confirmed off-site groundwater plume. This area is zoned for industrial purposes; therefore, there are no residential areas and, consequently, there are no private wells in use in this area. In fact, the only groundwater withdrawal occurring is from the dewatering operations of the quarry at lot Excess (613) near the eastern end of Union Valley. Contamination has never been detected in the quarry groundwater (DOE 1997). For these reasons, and because there is no point of exposure or receptor population for contaminated groundwater, ATSDR has determined that there are no *completed exposure pathways* for ingestion or direct contact with off-site groundwater.

Vapor Intrusion as a Potential Exposure Pathway

Vapor intrusion is the migration of volatile chemicals from subsurface soil or groundwater into overlying buildings (USEPA 2002c). Volatile organic compounds (VOCs) present in buried wastes in soil and/or in groundwater can emit vapors that may migrate through subsurface soils and into indoor air spaces of overlying buildings (NJDEP 2005). Often, the vapor concentrations in residences or occupied buildings are low and vapors may not be present at detectable levels,

based on the specific conditions of the site. In extreme cases, the vapors may accumulate to levels that may pose safety hazards, acute and/or chronic health effects, or aesthetic issues (USEPA 2002c). As such, vapor intrusion has evolved as a potential exposure pathway of consideration in the investigation of contaminated sites.

Three off-site monitoring wells (GW-169, GW-170, and GW-232) near the Y-12 Complex and within the known extent of the EEVOC groundwater contaminant plume contained twelve contaminants with at least one sample above CVs. The contaminants included the following: aluminum, arsenic, boron, carbon tetrachloride, chloroform, chromium, fluoride, iron, lead, tetrachloroethylene, thallium, and trichloroethylene (Table 4). Of the above-mentioned contaminants detected, only carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene are VOCs. The following VOCs were either absent or detected at concentrations below the CVs in all subsequent samples: chloroform, tetrachloroethylene, and trichloroethylene. In addition, sampling of off-site residential wells near the Y-12 Complex, including the nearest residential well (RWS 67) approximately 2.25 miles east of the known extent of the EEVOC plume, found no contaminants above CVs.

In evaluating potential exposure to groundwater contaminants via vapor intrusion, ATSDR considered the ORR groundwater hydrology. Nearly all groundwater beneath the ORR migrates to surface water before leaving the ORR boundaries. Therefore, additional migration of groundwater contamination off site is unlikely, due to the widespread diffuse discharge of groundwater into the surface water bordering the site.

No residences exist over the EEVOC groundwater contaminant plume. In addition, areas in Union Valley overlying the known extent of the contaminant plume are zoned as "Industrial District 2." There is, however, a portion of an office building overlying the mapped extent of the EEVOC plume in Union Valley (Figure 13). This office building is on Scarboro Rd. just east of the Y-12 Complex. The building is currently used by DOE contractors. Because the apparent extent of the EEVOC plume is beneath this building, it is necessary to evaluate the possibility of vapor intrusion into the workspaces within this building.

The EEVOC groundwater contaminant plume contains carbon tetrachloride, a contaminant of sufficient volatility to be of concern for vapor intrusion. In order to estimate the transport of contaminant vapors from a subsurface source into indoor air spaces, the Johnson-Ettinger Model (JEM) was developed as a screening level model (available at http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm). Since the JEM is a screening tool, it is based on several conservative assumptions regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction (USEPA 2004).

Since most of the required JEM input data are not collected during a typical site characterization, conservative inputs were estimated or inferred from available data and other non-site specific sources of information. A groundwater screening model was utilized to estimate the carbon tetrachloride vapor concentration in the building that overlays the EEVOC groundwater contaminant plume.

Table 7 outlines the conservative default parameters and assumptions used in the JEM. The JEM was used to consider carbon tetrachloride vapor intrusion into the building that overlays the EEVOC plume through two soil types (silt and silt clay). Because it is unknown whether the building has a basement or slab-on-grade, the JEM was used to consider both possibilities.

Table 7: JEM Groundwater Screening Model Variables for Vapor Intrusion of Carbon Tetrachloride1 into the Building that Overlays the Off-Site EEVOC Groundwater Plume

JEM Variable	*Silt Value*	*Silty Clay Value*	*Notes*
Depth below grade to bottom of enclosed space floor	200 cm (B)[2] 15 cm (S)[2]	200 cm (B) 15 cm (S)	Default parameters were used to consider a building constructed with a basement or on a slab.
Depth below grade to water table	364 cm (B) 179 cm (S)	393 cm (B) 208 cm (S)	Regardless of the depth to water, the JEM requires a minimum depth to account for capillary fringe. The capillary fringe is 164 cm for buildings that overlay silt and 193 cm for buildings that overlay silty clay. The shallowest depth allowed by the model was utilized for both the basement and slab scenarios.
Soil type directly above the water table	Silt (B) Silt (S)	Silty Clay (B) Silty Clay (S)	JEM was utilized to consider vapor intrusion into an occupational building with either a basement or a slab, which overlays two types of soil (silt and silty clay). Both types of soil are found in the area of the building.
Average groundwater temperature	15ºC (B) 15ºC (S)	15ºC (B) 15ºC (S)	Average shallow groundwater temperature for Tennessee was calculated by taking the average of the shallow groundwater zones north (14ºC) and south (16ºC) of the state of Tennessee (Figure 8; USEPA 2004).
Vadose zone soil type	Silt (B) Silt (S)	Silty Clay (B) Silty Clay (S)	JEM was utilized to consider vapor intrusion into an occupational building with either a basement or a slab, which overlays two types of soil (silt and silty clay). Both types of soil are found in the area of the building.
Vadose zone soil dry bulk density	1.50 g/cm^3 (B) 1.50 g/cm^3 (S)	1.50 g/cm^3 (B) 1.50 g/cm^3 (S)	The universal default parameter which is consistent with USEPA (1996a and b) for subsurface soils.
Vadose zone soil total porosity	0.43 (B) 0.43 (S)	0.43 (B) 0.43 (S)	The universal default parameter which is consistent with USEPA (1996a and b) for subsurface soils.
Vadose zone soil water-filled porosity	0.05 cm^3/cm^3 (B) 0.05 cm^3/cm^3 (S)	0.11 cm^3/cm^3 (B) 0.11 cm^3/cm^3 (S)	Conservative default parameters for the vadose zone silt and silty clay water-filled porosity (Table 10; USEPA 2004).

[1] The predominant VOC in the EEVOC groundwater contaminant plume is carbon tetrachloride. The maximum concentration (200 ppb) of carbon tetrachloride was detected (11/17/1994) above the CV from well GW-170, which is located within the known extent of the EEVOC.

[2] B = building with a basement; S= building built on a slab

Irrespective of the type of soil that underlies the building (silt or silty-clay), the carbon tetrachloride concentration was estimated to be slightly higher in a building with a basement, as opposed to a building with slab-on-grade construction (Table 8). To evaluate whether workers in this office building are being exposed to levels of VOCs that could potentially result in adverse health effects, ATSDR compared the JEM estimated carbon tetrachloride vapor concentrations to ATSDR's CVs, as well as to occupational exposure guidelines from the Occupational Health and Safety Administration (OSHA) and from the National Institute for Occupational Health and Safety (NIOSH) (Table 8).

Table 8: Estimated Vapor Concentration of Carbon Tetrachloride in the Office Building that Overlays the Off-Site EEVOC Groundwater Plume

Building	*Silt*	*Silty Clay*	*ATSDR CREG[1]*	*ATSDR EMEG[2]*	*OSHA PEL[3]*	*NIOSH REL[4]*
Basement	2.13 ppb	0.26 ppb	0.01 ppb	30 ppb	TWA = 10,000 ppb C = 25,000 ppb 200,000 ppb peak	ST = 2,000 ppb (60-minute)
Slab	1.80 ppb	0.22 ppb				

C = ceiling
ppb = part per billion
ST = short-term exposure limit
TWA = time-weighted average

[1] The cancer risk evaluation guide (CREG) is a highly conservative value that would be expected to cause no more than one excess cancer in a million persons exposed over time.

[2] The environmental media evaluation guide (EMEG) is a media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse non-carcinogenic health effects.

[3] Occupational Safety and Health Administration (OSHA) permissible exposure levels (PELs) are regulatory limits on the amount or concentration of a substance in the air one may be exposed to over an 8-hour workday during a 40-hour workweek.

- TWA concentrations for OSHA PELs must not be exceeded during any 8-hour work shift of a 40-hour workweek.
- OSHA ceiling concentrations (C) must not be exceeded during any part of the workday; if instantaneous monitoring is not feasible, the ceiling must be assessed as a 15-minute TWA exposure.
- There is also a 200,000 ppb peak, which means that a 5-minute exposure above the ceiling value, but never above the maximum peak, is allowed in any 4 hours during an 8-hour workday.

[4] The National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL) indicates a time-weighted average (TWA) concentration for up to a 10-hour workday during a 40-hour workweek. Specifically, the short-term exposure limit (ST) is a 15-minute TWA exposure that should not be exceeded at any time during a workday.

It is important to note that this evaluation was conservative for the following reasons:

* The maximum carbon tetrachloride concentration (200 ppb), rather than an average, from an off-site groundwater monitoring well in the EEVOC plume was used in the calculations. Further, carbon tetrachloride was only detected in 45 of 244 samples, and only 26 of these detections were higher than 7 ppb.

* Default parameters and assumption variables were entered into the model, due to the lack of information regarding the building characteristics and specific depth of the

EEVOC groundwater plume in this area. In general, using the default parameters for input variables will result in higher indoor air concentrations (USEPA 2004).

* ATSDR assumed that the EEVOC plume exists in the shallow, transient groundwater zone (between 1 and 7 feet below ground; USGS 1989). The depth below grade to water table variable was the smallest depth one could assume, given the inherent capillary fringe requirement.

In all instances, the estimated vapor concentrations of carbon tetrachloride in the office building are much less than ATSDR's environmental media evaluation guide (EMEG) and the OSHA and NIOSH regulatory limits. Even though the estimated vapor concentrations are above the cancer risk evaluation guide (CREG), ATSDR does not expect vapor intrusion to be a concern for the people who work in the building that overlays the EEVOC plume, especially given the conservative nature of the evaluation. The CREG is a highly conservative CV that is based on exposure in a residential setting 24 hours/day, every day of the year. Occupational (i.e., 8 hours/day, 40 hours/week) exposure would be much lower.

Based on currently available data and the results of the JEM, ATSDR concludes that groundwater *does not pose a public health hazard* via a vapor intrusion exposure pathway. Although the EEVOC groundwater contaminant plume emanating from the Y-12 complex has migrated off site, no residences overlay the plume. The nearest residence is approximately 2.25 miles east of the known extent of the EEVOC plume. One office building partially overlies the plume; however, conservative modeling indicates that estimated VOC concentrations are well below the EMEG and several orders of magnitude below the regulatory limits for occupational exposure.

Table 9: Exposure Pathways

Pathway	*1. Source of Contamination*	*2. Fate and Transport*	*3. Point of Exposure*	*4. Route of Exposure*	*5. Receptor Population*	*Time Frame*	*Conclusion for Pathway*
	Five Components of a **Completed** *Exposure Pathway*						
Contacting GW from Private wells in Union Valley	EEVOC Plume from the Y-12 Complex	Plume is migrating east along strike in the Maynardville Limestone Formation. It extends off-site into Union Valley.	**None.** There are no residences deriving drinking water from private wells in this area.			Past, Present, Future	**Incomplete**
Contacting groundwater from seeps and springs in Union Valley	EEVOC Plume from the Y-12 Complex	EEVOC plume has migrated off-site and discharges at various seeps and springs throughout Union Valley	**Potential** use of, or contact with, spring water from Union Valley.	Ingestion, dermal contact, inhalation	**None likely.** Seeps and springs feed Scarboro creek so isolated contact with groundwater from seeps and springs before dilution in surface water is unlikely.	Past, Present, Future	**Incomplete**
Inhaling VOCs via vapor intrusion into buildings in Union Valley	EEVOC Plume from the Y-12 Complex	EEVOC plume has migrated off-site under	**Working in the office building immediately east of Y-12.**	Inhalation	**Individuals working in the building**	Past, present, future	**Potentially Complete**

IV. Public Health Implications

ATSDR scientists have determined that there are no *completed exposure pathways* for ingestion or direct contact with off-site groundwater at ORR. The only confirmed contamination to have migrated off-site was from EEVOC contaminated groundwater plume originating in the Y-12 Complex. There has been no site-related groundwater contamination detected off-site either at the ETTP (former K-25 and S-10), or the ORNL (former X-10) facilities. This is likely due to the widespread diffuse discharge of groundwater into the surface water bordering the site. Groundwater is a known contributor to surface water contamination throughout the ORR. However, this PHA only addresses human exposure to off-site groundwater.

Y-12

The exposure investigation of this document addressed three possible exposure scenarios for contacting contaminated groundwater emanating from the Y-12 complex, two were eliminated because there are no points of exposure (i.e., contaminants have not been detected above CVs in private wells and there is no ready access to springs and seeps) and there is no receptor population. Exposure to the contaminated groundwater is unlikely to occur because there are no private wells and no residences near the EEVOC plume in Union Valley. The third possible exposure pathway – vapor intrusion into an office building overlying the EEVOC plume – has been conservatively modeled with results indicating estimated VOC concentrations well below occupational regulatory guidelines. ATSDR scientists have determined that there are *no public health implications* associated with contaminants from the Y-12 Complex.

ETTP and ORNL

A discussion of how the groundwater of the ORR typically flows has been presented in this document in the *Site Geology/Hydrogeology* section. There, it is illustrated that groundwater movement beneath streams and rivers in this area is limited at best. While it is true that water does occur beneath the stream beds, most is actually taken up into the stream flow (gaining stream system) through diffuse discharge from the groundwater. Some groundwater can be retained in the alluvium beneath and adjacent to the stream beds in the hyporheic zone, but core samples near the UEFPC indicate that there is a glei horizon beneath the stream bed which limits downward groundwater migration (USGS1989). Cracks and fissures in the karst rock formations underlying ORR significantly decrease with depth, thereby further limiting migration of contaminants to shallow plumes intercepted by surface water either by seeps and springs, which are common throughout the ORR, or as baseflow for creeks and streams. Also, site-related contaminants have not been detected beyond the ORR boundaries near either ETTP or ORNL in seeps/springs, monitoring wells or residential wells. For these reasons, ATSDR scientists have determined that there are *no public health implications* related to exposure to contaminated groundwater from either ETTP or ORNL.

V. Health Outcome Data Evaluation

Health outcome data are measures of disease occurrence in a population. Common sources of health outcome data are existing databases (cancer registries, birth defects registries, death certificates) that measure morbidity (disease) or mortality (death). Health outcome data can provide information on the general health status of a community—where, when, and what types of disease occurs and to whom it occurs. Public health officials use health outcome data to look for unusual patterns or trends in disease occurrence by comparing disease occurrences in different populations over periods of years. These health outcome data evaluations are descriptive epidemiologic analyses. They are exploratory as they may provide additional information about human health effects and they are useful to help identify the need for public health intervention activities (for example, community health education). However, health outcome data cannot—and are not meant to—establish cause and effect between environmental exposures to hazardous materials and adverse health effects in a community.

ATSDR scientists generally consider health outcome data to evaluate the possible health effects in a population known to have been exposed to enough environmental contamination to experience health effects. In this pubic health assessment on off-site groundwater at ORR, ATSDR scientists determined that people were not and are not using private groundwater wells and were not exposed to ORR related contaminants from groundwater exposure. For these reasons, health outcome data will not be evaluated in this public health assessment.

VI. Community Health Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. ATSDR actively gathers comments and other information from the people who live or work near the ORR. ATSDR is particularly interested in hearing from residents of the area, civic leaders, health professionals, and community groups.

To improve the documentation and organization of community health concerns at the ORR, ATSDR developed a *Community Health Concerns Database* that is specifically designed to compile and track community health concerns related to the site. The database allows ATSDR to record, track, and respond appropriately to all community concerns, and also to document ATSDR's responses to these concerns. From 2001 to 2003, ATSDR compiled more than 2,500 community health concerns obtained from the ATSDR/ORRHES community health concerns comment sheets, written correspondence, phone calls, newspapers, comments made at public meetings (ORRHES and work group meetings), and surveys conducted by other agencies and organizations. These concerns were organized in a consistent and uniform format and imported into the database.

The community health concerns addressed in this public health assessment are those concerns in the ATSDR Community Health Concerns Database that are directly related to issues associated with groundwater contamination on-site and movement of the contaminant plume off-site. Table 10 contains the actual comments and ATSDR's responses.

Table 10: Community Health Concerns from the Oak Ridge Reservation Community Health Concerns Database and ATSDR Responses

#	*Comment*	*ATSDR Response*
1	Is the groundwater helping to contribute to kidney cancer? -and, Past exposures to arsenic from groundwater may have resulted in high levels of arsenic in my body.	Since ATSDR scientists have concluded that there is no exposure to contaminated groundwater from ORR (see the *Evaluation of Environmental Contamination and Potential Exposure Pathways* section of this document), it is unlikely that any incidence of kidney cancer or elevated levels of arsenic in the body of citizens in the surrounding area is attributable to consumption of groundwater.
2	Groundwater flows from the Y-12 plant to Scarboro.	The East End Volatile Organic Compound (EEVOC) plume flows east-northeast along strike, paralleling the underlying geology. Current DOE plume mapping indicates that the EEVOC is entirely in the Maynardville Limestone (part of the Conasauga Group – See Figure B-1), an aquifer formation with relatively high hydraulic conductivity. The Scarboro community is located on the Rome formation that consists of low-conductivity shales and siltstones. It is unlikely that water will migrate from areas with higher hydraulic conductivity to those with less.
3	What effect do the solid waste storage areas have on groundwater?	Solid waste storage areas (SWSA) are discussed in the *Melton Valley Watershed* section of this document.
4	Concern that communities that share a limestone slab with a burial ground or dumping ground might have contaminated groundwater.	A thorough investigation of the underlying geology of the ORR and surrounding areas, as well as the contaminated groundwater from ORR, with respect to the communities nearby is the focus of this public health assessment. We hope that the specific information we have presented in this PHA about each of the facilities at ORR has answered this general question about public contact with contaminated groundwater. For specific information regarding the geology and hydrology of the ORR, please refer to Appendix B.

VII. Conclusions

It is important for the reader to understand that ATSDR scientists acknowledge the fact that karst systems are notoriously difficult to fully characterize with respect to groundwater flow direction and rate. We have based our conclusions on currently available data concerning groundwater flow and specific contaminant fate and transport from well monitoring data. There are large solution cavities beneath ORR and the surrounding area which are often interconnected and have high flow rates. Some have been encountered in various well drilling activities or by casual observation, and some have yet to be discovered. Our conclusions are based upon well supported information of groundwater flow and contaminant transport. While much is unknown or fully understood about karst systems in general, it is our intention to assess the currently available data, and to arrive at a conclusion of whether the community has had (or is currently having) an exposure to contaminants in off-site groundwater.

Another point of consideration is that of the possibility of the over-pumping of groundwater wells creating a negative hydraulic gradient which could draw contaminants against the normal flow of groundwater. It is true that heavy well pumping can create a negative hydraulic gradient and cause groundwater to flow toward the well in all directions. Also, the theoretical potential exists for contaminated water to be drawn from surface water sources. However, based on available data, we do not believe this is occurring in residential wells or monitoring wells surrounding the reservation.

This public health assessment addresses off-site (community) exposures to contaminated substances released to the groundwater from the Oak Ridge Reservation. Having thoroughly evaluated past public health activities and available current environmental information, ATSDR has reached the following conclusions:

- Although extensive groundwater contamination exists throughout the ORR, ATSDR scientists have concluded that there is ***No Public Health Hazard*** from exposure to contaminated groundwater emanating from ORR. This conclusion category is used for sites that, because of the absence of exposure, do not pose a public health hazard. Sufficient evidence exists that no human exposures to contaminated groundwater have occurred, no exposures are currently occurring, and exposures are not likely to occur in the future (ATSDR 2005). The EEVOC plume emanating from the Y-12 complex is the only confirmed off-site groundwater plume. Table 9 illustrates the three exposure scenarios that were considered for this public health assessment: 1) contacting groundwater from private wells in Union Valley, 2) contacting groundwater from seeps and springs in Union Valley, and 3) vapor intrusion in to the off-site office building east of Y-12. Based on the fact that groundwater has short flow paths to surface water in this area and that there are no private wells pumping groundwater in this area, ATSDR scientists concluded that there were *no completed exposure pathways* for ingestion or direct contact with off-site groundwater. Also, extremely conservative modeling indicates that estimated VOC concentrations in the office building are much less than ATSDR's EMEG and the OSHA and NIOSH regulatory limits. Even though the estimated vapor concentrations are above the extremely conservative CREG, ATSDR does not expect vapor intrusion to be a concern for the people who work in the building that overlays the EEVOC plume.

- Groundwater and surface water are highly interconnected throughout the ORR. Groundwater flow in this area (ORR) is influenced largely on the extent of fractures in the bedrock which create preferential flow paths. In the regional aquifers of East Tennessee, including those underlying the ORR, fractures in bedrock are typically limited to the upper extents of the bedrock formations and significantly decrease with depth (MMES 1986, USGS 1986b, USGS 1988, USGS 1989, SAIC 2004). The numerous springs and seeps in the area support the notion of a very active shallow groundwater system in the ORR. Also, groundwater will flow along bedding planes and along strike, especially in areas where carbonate units have well-developed conduit systems (ORNL 1982, USGS 1997). Therefore, groundwater constitutes much of the baseflow of many streams and tributaries in the area, including East Fork Poplar Creek (USGS 1989, SAIC 2004). It is unlikely that contaminated groundwater at the ORR will flow beneath, and continue to flow away from, streams and rivers that surround the site. Indeed, the incised meander (see Appendix A) of the Clinch River in bedrock represents a major topographic feature that prevents groundwater from passing beneath the river (ORNL 1982).

VIII. Recommendations

Having evaluated past public health activities and the available environmental information, ATSDR recommends that the community be informed that ATSDR has evaluated off-site groundwater contamination from the Oak Ridge Reservation and has concluded that there is *no public health hazard* associated with past and current releases.

In this PHA, ATSDR scientists used every data source available to compile a database of off-site groundwater sampling results, albeit from monitoring wells, residential wells, or from seeps and springs nearby. While CERCLA requires groundwater monitoring, residential well sampling is not regularly conducted by either the State of Tennessee or by DOE. Therefore, we recommend that a regular periodic residential well-sampling program be initiated in order to assure that these wells remain free of ORR site-related contaminants.

ATSDR also recommends that institutional controls set forth in the Interim Record of Decision for Union Valley (Jacobs EM Team 1997a) remain in place to prevent exposure to contaminated groundwater. These controls should remain in place until all off-site contamination in Union Valley is reduced to below levels of health concern.

IX. Public Health Action Plan

The public health action plan for the Oak Ridge Reservation (ORR) contains a description of actions taken at the site and those to be taken at the site following the completion of this public health assessment. The purpose of the public health action plan is to ensure that this public health assessment not only identifies potential and ongoing public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to harmful substances in the environment. The following public health actions at the ORR are completed, ongoing, or planned:

Completed Actions

- In 1991, the Tennessee Department of Health (TDOH) began a two-phase research project to determine whether environmental releases from ORR harmed people who lived nearby. Phase I focused on assessing the feasibility of doing historical dose reconstruction and identifying contaminants that were most likely to have effects on public health. Phase II efforts included full dose reconstruction analyses of iodine 131, mercury, polychlorinated biphenyls (PCBs), and radionuclides, as well as a more detailed health effects screening analysis for releases of uranium and other toxic substances (a summary can be found in the *Oak Ridge Dose Reconstruction Project Summary Report, Volume 7*). Phase II was completed in January 2000. All of the final reports from Phase I and Phase II of the Oak Ridge Environmental Dose Reconstruction Project are accessible from the DOE public use database called Comprehensive Epidemiologic Data Resource (CEDR). This database contains information pertinent to health-related studies performed at Oak Ridge Reservation and other DOE sites. The URL for the Phase I and Phase II Dose Reconstruction Project is – http://cedr.lbl.gov/DR/dror.html.

- In 1992, the U.S. Department of Energy (DOE) conducted a *Background Soil Characterization Project* in the area around Oak Ridge (DOE 1993).

- In 1993, ATSDR evaluated public health issues related to past and present releases into the creek from the Y-12 Complex in a health consultation, *Y-12 Weapons Plant Chemical Releases Into East Fork Poplar Creek* (ATSDR 1993).

- In 1996, ATSDR evaluated the current public health issues related to the past and present releases into the Lower Watts Bar Reservoir from the ORR in a *Health Consultation on the Lower Watts Bar Reservoir* (ATSDR 1996).

- In 1998, the Environmental Sciences Institute at Florida Agricultural and Mechanical University (FAMU), along with its contractual partners at the Environmental Radioactivity Measurement Facility at Florida State University, and the Bureau of Laboratories of the Florida Department of Environmental Protections, as well as DOE subcontractors in the Neutron Activation Analysis Group at Oak Ridge National Laboratory and the Jacobs Engineering Environmental Management Team, sampled soil, sediment, and surface water from Scarboro to address community concerns about environmental monitoring in the neighborhood (FAMU 1998).

- In 2001, the U.S. Environmental Protection Agency (EPA) collected samples of soil, sediment, and surface water from the Scarboro community to address community concerns and verify the results of the 1998 sampling conducted by FAMU (EPA 2003).

- In 2004, the Agency for Toxic Substances and Disease Registry (ATSDR) released the final ORR Public Health Assessment for Y-12 Uranium Releases.

Ongoing Actions

- ATSDR will continue to evaluate contaminants and pathways of concern to the community surrounding the reservation. In addition to this evaluation of groundwater, ATSDR is evaluating uranium from the Y-12 Complex, uranium and fluorides from the K-25 facility, iodine 131, mercury, White Oak Creek releases in the 1950s, PCBs, and the TSCA incinerator.

- In 1999, the Oak Ridge Reservation Health Effects Subcommittee (ORRHES) was created under the guidelines and rules of the Federal Advisory Committee Act to provide a forum for communication and collaboration between citizens and the agencies that are evaluating public health issues and conducting public health activities at the ORR. The ORRHES serves as a citizen advisory group to CDC and ATSDR and provides recommendations on matters related to public health activities and research at the reservation. It also provides an opportunity for citizens to collaborate with agency staff members, to learn more about the public health assessment process and other public health activities, and to help prioritize public health issues and community concerns to be evaluated by ATSDR.

- DOE has developed a Groundwater Strategy document (USDOE 2004) that lays out a plan for making future decisions on groundwater remediation on the ORR on a watershed scale. Previously, groundwater contamination had been dealt with on a site-by-site basis. The goal is to evaluate various groundwater remediation technologies for that areas within the same water transport system (watershed) and have similar contamination problems and land uses in an effort to increase cost-effectiveness.

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Appendix A. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption
The process of taking in. For a person or animal, *absorption* is the process through which a substance gets into the body through the eyes, skin, stomach, intestines, or lungs.

Activity
The number of radioactive nuclear transformations occurring in a material per unit time. The term for *activity* per unit mass is specific activity.

Acute
Occurring over a short time [compare with **chronic**].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate-duration exposure** and **chronic exposure**].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Ambient
Surrounding (for example, *ambient* air).

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Background radiation
The amount of radiation to which a member of the general population is exposed from natural sources, such as terrestrial radiation from naturally occurring **radionuclides** in the soil, cosmic radiation originating from outer space, and naturally occurring radionuclides deposited in the human body.

Bedding planes
The division of *sediment* or *sedimentary rock* into parallel layers (beds) that can be distinguished from each other by such features as chemical composition and grain size.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA
[See **Comprehensive Environmental Response, Compensation, and Liability Act of 1980.**]

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate-duration exposure**].

Committed Effective Dose Equivalent (CEDE)
The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to the organs or tissues. The *committed effective dose equivalent* is used in radiation safety because it implicitly includes the relative carcinogenic sensitivity of the various tissues. The unit of dose for the CEDE is the rem (or, in SI units, the sievert—1 sievert equals 100 rem.)

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway
[See **exposure pathway.**]

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as **Superfund,** is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by *CERCLA,* is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other medium.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Curie (Ci)
A unit of radioactivity. One *curie* equals that quantity of radioactive material in which there are 3.7×10^{10} nuclear transformations per second. The activity of 1 gram of radium is approximately 1 Ci; the activity of 1.46 million grams of natural uranium is approximately 1 Ci.

Decay product/daughter product/progeny
A new nuclide formed as a result of radioactive decay: from the radioactive transformation of a radionuclide, either directly or as the result of successive transformations in a radioactive series. A *decay product* can be either radioactive or stable.

Depleted uranium (DU)
Uranium having a percentage of U 235 smaller than the 0.7% found in natural uranium. It is obtained as a byproduct of U 235 enrichment.

Dermal
Referring to the skin. For example, *dermal* absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see **route of exposure**].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOE
The United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. *Dose* is a measurement of exposure. *Dose* is often expressed as milligrams (a measure of quantity) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the *dose,* the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually gets into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation *dose* is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [**dose**] to a substance and the resulting changes in body function or health (response).

EMEG
Environmental Media Evaluation Guide, a media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse noncarcinogenic health effects.

Enriched uranium
Uranium in which the abundance of the U 235 isotope is increased above normal.

Environmental media
Soil, water, air, **biota** (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and **biota** (plants and animals). *Transport mechanisms* move contaminants from the source to points where human exposure can occur. The *environmental media and transport mechanism* is the second part of an **exposure pathway.**

EPA
The United States Environmental Protection Agency.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Equilibrium, radioactive
In a radioactive series, the state that prevails when the ratios between the activities of two or more successive members of the series remain constant.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. *Exposure* can be short-term [see **acute exposure**], of intermediate duration [see **intermediate-duration exposure**], or long-term [see **chronic exposure**].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biological tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An *exposure pathway* has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through **groundwater**); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the *exposure pathway* is termed a **completed exposure pathway.**

Exposure registry
A system of ongoing follow up of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Half-life ($t_{½}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the *half-life* is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the *half-life* is the time it takes for half the original amount of the substance to disappear either by being changed to another substance or by leaving the body. In the case of radioactive material, the *half-life* is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into other atoms (normally not radioactive). After two *half-lives,* 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. *Health consultations* are focused on a specific exposure issue. They are therefore more limited than public health assessments, which review the exposure potential of each pathway and chemical [compare with **public health assessment**].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A *health statistics review* is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with **prevalence**].

Incised Meander
Incised meanders result from down-cutting along the deepest part of a river's channel. The down-cutting is so rapid, the river maintains a meandering pattern while deepening its valley. This erosion process creates exposed bedrock on its banks permitting the discharge of groundwater to surface streams.

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate-duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

Ionizing radiation
Any radiation capable of knocking electrons out of atoms and producing ions. Examples: alpha, beta, gamma and x rays, and neutrons.

Isotopes
Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Identical chemical properties exist in *isotopes* of a particular element. The term should not be used as a synonym for "nuclide," because "isotopes" refers specifically to different nuclei of the same element.

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

mg/kg

Milligrams per kilogram.
mg/m^3

Milligrams per cubic meter: a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. *MRLs* are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). *MRLs* should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes **mutations** (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The *NPL* is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL
[See **National Priorities List for Uncontrolled Hazardous Waste Sites.**]

Parent
A radionuclide which, upon disintegration, yields a new nuclide, either directly or as a later member of a radioactive series.

Plume
A volume of a substance that moves from its source to places farther away from the source. *Plumes* can be described by the volume of air or water they occupy and the direction in which they move. For example, a *plume* can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with **incidence**].

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action plan
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed by coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **health consultation**].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or **radionuclides** that could result in harmful health effects.

Public health hazard categories
Statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five *public health hazard categories* are **no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard,** and **urgent public health hazard.**

Public health statement
The first chapter of an ATSDR **toxicological profile.** The *public health statement* is a summary written in words that are easy to understand. It explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Quality factor (radiation weighting factor)
The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses - on a common scale for all ionizing radiation - the approximate biological effectiveness of the absorbed dose.

Rad
The unit of absorbed dose equal to 100 ergs per gram, or 0.01 joules per kilogram (0.01 gray) in any medium [see **dose**].

Radiation
The emission and propagation of energy through space or through a material medium in the form of waves (e.g., the emission and propagation of electromagnetic waves, or of sound and elastic waves). The term "radiation" (or "radiant energy"), when unqualified, usually refers to electromagnetic *radiation.* Such *radiation* commonly is classified according to frequency, as microwaves, infrared, visible (light), ultraviolet, and x and gamma rays and, by extension, corpuscular emission, such as alpha and beta *radiation,* neutrons, or rays of mixed or unknown type, such as cosmic *radiation.*

Radioactive material
Material containing radioactive atoms.

Radioactivity
Spontaneous nuclear transformations that result in the formation of new elements. These transformations are accomplished by emission of alpha or beta particles from the nucleus or by the capture of an orbital electron. Each of these reactions may or may not be accompanied by a gamma photon.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RBC
Risk-based Concentration, a contaminant concentration that is not expected to cause adverse health effects over long-term exposure.

RCRA
[See **Resource Conservation and Recovery Act (1976, 1984).**]

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Rem
A unit of dose equivalent that is used in the regulatory, administrative, and engineering design aspects of radiation safety practice. The dose equivalent in *rem* is numerically equal to the absorbed dose in rad multiplied by the quality factor (1 *rem* is equal to 0.01 sievert).

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RfD
[See **reference dose.**]

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three *routes of exposure* are breathing [**inhalation**], eating or drinking [**ingestion**], and contact with the skin [**dermal contact**].

Safety factor
[See **uncertainty factor**.]

Sample
A portion or piece of a whole; a selected subset of a population or subset of whatever is being studied. For example, in a study of people the *sample* is a number of people chosen from a larger population [see **population**]. An environmental *sample* (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sievert (Sv)
The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose, in gray, multiplied by the quality factor (1 sievert equals 100 rem).

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A *source of contamination* is the first part of an **exposure pathway.**

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, gender, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered *special populations.*

Specific activity
Radioactivity per unit mass of material containing a radionuclide, expressed, for example, as Ci/gram or Bq/gram.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Strike
The horizontal line marking the intersection between the inclined plane of a solid geological structure and the Earth's surface.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Surveillance
[see **epidemiologic surveillance**]

Survey
A systematic collection of information or data. A *survey* can be conducted to collect information from a group of people or from the environment. *Surveys* of a group of people can be conducted by telephone, by mail, or in person. Some *surveys* are done by interviewing a group of people.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A *toxicological profile* also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Uncertainty factor
A mathematical adjustment for reasons of safety when knowledge is incomplete—for example, a factor used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). *Uncertainty factors* are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use *uncertainty factors* when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

Units, radiological

Units	*Equivalents*
Becquerel* (Bq)	1 disintegration per second = 2.7×10^{-11} Ci
Curie (Ci)	3.7×10^{10} disintegrations per second = 3.7×10^{10} Bq
Gray* (Gy)	1 J/kg = 100 rad
Rad (rad)	100 erg/g = 0.01 Gy
Rem (rem)	0.01 sievert
Sievert* (Sv)	100 rem

*International Units, designated (SI)

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Watershed
A watershed is a region of land that is crisscrossed by smaller waterways that drain into a larger body of water.

Water table
The surface that lies between the *unsaturated zone* and the underlying *saturated zone* of the soil.

Other Glossaries and Dictionaries
Environmental Protection Agency http://www.epa.gov/OCEPAterms/
National Center for Environmental Health (CDC) http://www.cdc.gov/nceh/dls/report/glossary.htm
National Library of Medicine http://www.nlm.nih.gov/medlineplus/mplusdictionary.html